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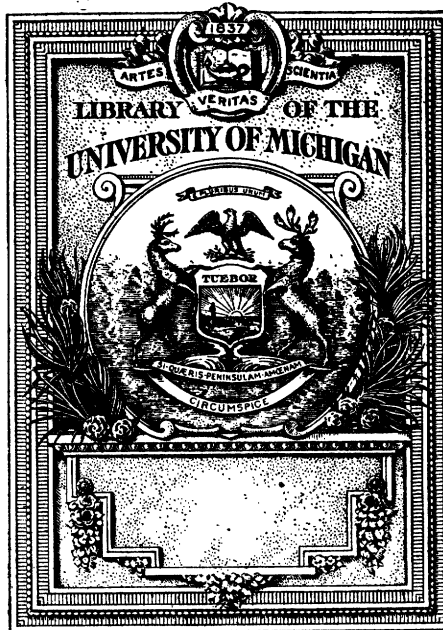
Board of Estimate *and* Apportionment

PRELIMINARY REPORT OF A
SPECIAL COMMITTEE CON-
SISTING OF THE CHIEF EN-
GINEER OF THE BOARD OF
ESTIMATE AND APPORTION-
MENT, THE COMMISSIONER
OF DOCKS, THE COMMIS-
SIONER OF PLANT AND
STRUCTURES, AND THE EN-
GINEER OF THE BOROUGH
OF RICHMOND

222

Concerning
**THE BROOKLYN-RICHMOND FREIGHT AND
PASSENGER TUNNEL**

OCTOBER FIFTEENTH, NINETEEN TWENTY-ONE



THE GIFT OF
N.Y. City Bd. of Estimate
AND Apportionment

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New York City Bd of Estimate
and Apportionment
9-8-1925

CITY OF NEW YORK
BOARD OF ESTIMATE AND APPORTIONMENT

October 15, 1921.

Hon. JOHN F. HYLAN,
Mayor.

SIR:

On May 20, 1921, the undersigned were appointed by the Board of Estimate and Apportionment as a Committee to confer with representatives of the Pennsylvania, Long Island and Baltimore & Ohio Railroads with respect to the development of a plan for the joint use of the proposed Brooklyn-Richmond freight and passenger tunnel, which under the provisions of Chapter 700 of the Laws of 1921 the Board of Estimate and Apportionment has been directed to construct.

This action was followed on June 17th by an appropriation of \$150,000 for meeting a part of the preliminary expenses incidental to the development of plans, and the Chief Engineer of the Board was directed to assume charge of the undertaking.

In order that the Board may be informed as to the present status of this enterprise, the Committee begs to present the following as a preliminary report:

It was the understanding of your Committee that the railroad companies named by the Board in its resolution appointing the Committee were selected because they represented the lines which seemed by reason of location to be most directly related to the tunnel project, but after several informal discussions with their representatives and a further study of the problem, the conclusion was reached that the project concerned every one of the trunk line railroads entering the Metropolitan District, and in that belief a conference was held by Your Honor, at the suggestion of this Committee, with the executives of all these railroads with the sole exception of one which apparently felt that its interests were too remote to be materially affected.

At this conference, held on July 28th, it was the consensus of opinion that before progress could be made the engineering features would have to be developed, and to this end a resolution was adopted recommending the creation of an engineering committee, consisting of an engineer to be named by the President of each of the railroads and the Chief Engineer of the Board, with directions to report back on August 16th to an executive Committee, consisting of Your Honor and the Presidents of the railroads

represented. A preliminary report of the engineering committee was presented at the next meeting, when adjournment was taken to October 25th, with the understanding that sufficient information would then be developed by the engineering committee to permit of constructive action.

The report of the Chief Engineer of the Board, accompanied by those from his consulting staff and Tunnel Engineer, to the engineering committee of the railroads reviews the work which has been done, and is presented herewith to show the progress which has been made and the scope proposed for the undertaking.

In first considering the problem it was proposed to link the tunnel with the Long Island Railroad on the Brooklyn side of the Narrows and with the Baltimore & Ohio Railroad on the Staten Island side, in the belief that through the use of existing trackage it would be possible to connect most of the trunk line railroads of the Metropolitan District and to secure connections with the remaining roads by the construction of short links, and it was also thought that the two tubes under consideration might be used for both trunk line freight and passenger traffic as well as for local passenger service. At an early stage of the investigation it developed that the volume of tonnage which would have to be served was entirely too great to permit the use of the same tubes for both trunk line and local passenger service or of introducing the former on to the Baltimore & Ohio tracks east of the Arlington Yard on Staten Island, and a further study showed that present congestion on all other lines which could be availed of for the development of a belt line trunk railroad in the territory adjacent to Newark Bay was already too pronounced to justify an effort to still further crowd them by attempting to use them for the required interchange of freight between the roads to be served. To meet this condition the trunk line feature of the project has been expanded greatly beyond the scope originally contemplated and as planned by the engineers is designed to fully meet, in a practical and broad way, all the objections which have been raised to other schemes.

The general features are shown on the accompanying map, on which there are also indicated suggested routes for industrial railroads along portions of the City waterfront where such facilities are now or soon will be needed.

In the judgment of your Committee, the project as outlined in the accompanying report should be pressed to a successful conclusion as being advantageous to every interest affected, and as representing the greatest stride that has ever been taken toward the proper solution of the Port of New York problem.

In its behalf there may be claimed:

- (1) A maximum benefit to the Port at a lesser cost than under any comprehensive project heretofore submitted for public consideration;

(2) The provision of all-rail delivery from each of the trunk line railroads direct into each of the Boroughs of the City and to all parts of its industrial and commercial waterfront;

(3) Provision for the industrial development along modern lines of great waterfront areas within the City limits which are now lying dormant simply for lack of rail facilities, such as Jamaica Bay, Flushing Bay, the east side of The Bronx, and Staten Island, thereby relieving the present overflow, which is obliged to seek such privileges outside the State limits, and without interference with present development;

(4) Decreased cost of delivering freight into all parts of the City due to—

- (a) Decrease in mileage for trucking;
- (b) Decrease in car detention;
- (c) Decrease in cost of rail service.

(5) The removal of one of the serious sources of congestion of street traffic and particularly along the Hudson River waterfront in lower Manhattan, by relieving all portions of the City from other than its local freight business;

(6) The provision of a connection between the City and the territory west of the Hudson River for the delivery of coal and food supplies, irrespective of harbor conditions;

(7) The encouragement of shipping through the offering of direct all-rail connections with piers provided with modern equipment and warehouses on main channels near to the ocean and removed from the congested lines of travel;

(8) An opportunity for the trunk line railroads to obtain greatly expanded facilities and at the same time increase their net revenue at the very outset;

(9) The means for introducing passenger stations in all boroughs for the mutual convenience of the trunk line railroads and their patrons;

(10) A most valuable factor in the defense of the City in case of war.

In the scant time interval which has elapsed since studies were begun, it has not seemed practicable to develop the local passenger service feature of the project beyond the stage of insuring the line a position suitable to meet the needs of the Borough of Richmond, nor would it seem advantageous to do so until after the trunk line railroads have been given an opportunity to join the City in carrying out the belt line portion of the plan. Steps toward meeting the local passenger service needs will be included in the plan before it is completed.

The Committee recommends that it be authorized, on behalf of the City, to make application to the proper Federal authorities for permission to

make such borings as are required to permit of the preparation of construction plans, and to secure approval of such type of construction as may be determined upon.

Respectfully submitted,

ARTHUR S. TUTTLE,
Chief Engineer,
Board of Estimate and Apportionment.
MURRAY HULBERT,
Commissioner of Docks.
GROVER A. WHALEN,
Commissioner of Plant and Structures.
THEODOR S. OXHOLM,
Engineer, Borough of Richmond.

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BOARD OF ESTIMATE AND APPORTIONMENT
Office of the Chief Engineer

ARTHUR S. TUTTLE,
Chief Engineer.

October 15, 1921.

To the Engineering Committee representing the Trunk Line Railroads entering the Metropolitan District.

GENTLEMEN:

At the conference held on August 16 between His Honor, the Mayor, and the executives of the trunk line railroad companies entering the Metropolitan District, with respect to the development of a plan for the joint use of the proposed Brooklyn-Richmond freight and passenger tunnel, adjournment was taken to October 25 with the understanding that in the meantime the project would be more fully developed by the Engineering Committee. During the lapsed interval the matter of tunnel route and grade has been made the subject of intensive study by this office and the planning of connections with all of the trunk line railroads has also received careful consideration. Valuable data to serve as the basis for the latter investigation have been furnished by members of your Committee, and have been availed of.

At the conference held between the members of this Committee on August 9 the original suggestions as to the possible inclusion of a portion of the Pennsylvania Railroad right-of-way in a proposed inner belt line to reach the northern tier of railroads, and of a connection between the New York Central and the New York, New Haven and Hartford Railroads by a line following the east side of the Harlem River were abandoned, the former on the ground of present congestion and the latter as impracticable for this and other reasons. A substitute route for the connection in New Jersey was then proposed, largely dependent upon a partial appropriation of the right-of-way of the Central Railroad of New Jersey and the construction of a short link between this road and the Erie, but later advices received from the Chief Engineer of the Jersey Central show that all of the existing facilities of this road will be required to meet its own needs. Studies have been made by the Chief Engineer of the New York Central Railroad of various methods of securing a connection with the proposed Belt Line Railroad, but without reaching a definite conclusion, and one is now proposed by this office which seems to have peculiar advantages both as to location and economy in construction. No constructive suggestions have been received with respect to alternative projects for a belt line to intercept all of the roads on the New Jersey side, while, on the other hand, the information now available seems to establish the impracticability of building up such a belt through the use of lines now in existence in the

highly developed section, all of which appear to be saturated, or nearly so, with the present traffic.

Under these conditions it would seem that an entirely new belt line is required, the location of which of necessity must be in territory less intensively developed with railroads that is that bordering on and at the head of Newark Bay.

The general route which has been selected as most advantageous for the belt line now suggested, in order to serve all of the railroads, this including the proposed Narrows Tunnel and the territory on the New Jersey side, as well as the connection between the New York Central and the New York, New Haven and Hartford Railroads and a connection with the new Stapleton piers, thereby introducing all rail service into every Borough of the City, is shown on an accompanying map prepared for the Special Committee appointed by the Board of Estimate and Apportionment to consider the matter, which map also indicates the location of a proposed industrial railroad traversing the intensively developed Brooklyn waterfront along the Upper Bay, East River and Newtown Creek, the inclusion of which in the project would seem desirable.

It might be noted that the proposed route from Haworth, N. J., to the Narrows Tunnel follows very closely one that was selected by Consulting Engineer Wilgus in 1911, and which through the northerly portion was independently located by Tunnel Engineer Snow in 1918. It has been made the subject of reconnaissance by the Consulting Engineers and the Tunnel Engineer in connection with the development of the present project and an aerial survey has been made of the line.

Routes for other industrial railroads are also shown on this map, designed to bring about the development of Jamaica Bay, the great area adjoining Arthur Kill on the Richmond side, Flushing Bay and Flushing River, the Hunt's Point Section of the Borough of The Bronx, and portions of the Harlem waterfront which can easily be reached; the need for still additional lines in all of the Boroughs is pronounced but they are not shown on the plan for the reason that they are not at this time susceptible of as definite routing as in the cases of those now suggested. The timeliness of at least many of these latter projects is manifest to those familiar with what will be their advantages as soon as jointly operated all rail facilities can be provided, as is clearly evidenced in the case of the Arthur Kill territory by an inspection of the activity of similar waterfront property on the New Jersey side where rail service is rendered by the Jersey Central Railroad. The secondary industrial belt lines are featured on the plan as indicative of the magnitude which this project should assume in the matter of an expansion of industrial and port facilities, and it is believed that their construction can to at least a considerable extent be arranged for prior to the completion of the main belt.

A copy of a report upon the tunnel feature of the project prepared by



From aerial survey

ARTHUR KILL AT PRALL'S ISLAND, SHOWING ABSENCE OF DEVELOPMENT ON
STATEN ISLAND SIDE WHERE RAIL FACILITIES ARE LACKING

(Anchored vessels are property of the U. S. Shipping Board—the ruins of a recently burned
plant on the New Jersey side are visible in this picture)

Tunnel Engineer Jesse B. Snow is presented herewith, giving data which have been requested in previous discussions. Plans have been developed along fifteen separate and distinct routes based in each case on the utilization of either a one per cent. maximum grade or a two per cent. maximum grade. The latter gradient has been decided upon in the interest of economy, the construction costs being thereby decreased more than \$15,000,000.

There is also presented an analysis of the belt line project by Consulting Engineer William J. Wilgus and concurred in by Consulting Engineer John F. Sullivan, including also the suggested industrial line along the Brooklyn waterfront, but excluding the connection between the New York, New Haven & Hartford and the New York Central Railroads. From this review it would seem evident that the financial as well as other advantages to be gained by carrying out the project are great enough to serve as a strong incentive to its inauguration, and in the belief that a review of what has been done in the matter of constructing and operating belt line railroads for joint use in other parts of the country would be of value in pointing the way for putting into execution the project now under discussion, Consulting Engineer Wilgus has, at my request, compiled a review of a number of similar undertakings which have been made the subject of official reports. The traffic statistics on which Consulting Engineer Wilgus' analysis is based appear to be more than conservative. They do not include the 12,000,000 or more tons to be developed annually from the new piers at Stapleton, all of which are under lease, nor do they include a very substantial present movement across the harbor which is of a more or less intangible character owing to lack of statistics and which would doubtless seek this belt line not only as a more direct but also as a more economical route, and particularly in the case of freight from the northern tier of New Jersey railroads. As an illustration of this traffic, there might be cited the great volume of milk and produce brought into the City daily which does not appear as "interchange freight," and which is now delivered by long Interstate and Interborough truck haul and at correspondingly great expense.

It will be noted that the estimate presented by Tunnel Engineer Snow is based on the use of a shield tunnel leaving Staten Island near the Quarantine Station and designated on the plan as the South Route. This tunnel, he estimates, can be constructed at a lesser cost than if the same type of tunnel is constructed on what is designated as the North Route. Consulting Engineers Wilgus and Sullivan express the opinion that a trench tunnel could be built in the northerly location at a cost not more than that estimated by Tunnel Engineer Snow for a shield tunnel in the southerly location. The special advantages of each of these routes are set forth in their reports, but pending progress with studies for a trench construction project, and the making of necessary borings, it does not seem wise at this time to make a final decision as to the choice between these routes, but rather to leave the matter open for further investigation. In any event, it would seem clear that the project is entirely practicable and

that the total cost of the proposed tunnel and its terminal connections may be estimated at about \$51,000,000.

The connection suggested between the New York Central and the New York, New Haven & Hartford Railroads, designed to bring the former road into the belt line, has been made the subject of study and report by Consulting Engineer Sullivan, of which a copy is annexed hereto. This plan seems to be free from the objections heretofore raised and not only avoids the congested trackage along the Harlem River but will here afford new industrial facilities and connect directly into the west side north and south line at an advantageous point.

Lack of time has prevented field work beyond the reconnaissance stage or the preparation of plans in anything like detail, but it is believed that the studies as now offered are based on sufficient data to enable those interested to reach a sound conclusion as to the advantages of the project.

A summary of the data developed shows the following:

Estimated minimum tonnage per year to be carried by the belt line railroad as representing present sources of freight interchange and a portion of the service of the Brooklyn water front	22,500,000 tons
--	-----------------

Cost of belt line railroad complete from Haworth, N. J., to and including the proposed classification yard in the Borough of Richmond, say	\$42,000,000 00
Cost complete of trunk line freight and passenger tunnel across the Narrows, extending from the proposed classification yard in the Borough of Richmond to the connection with the Long Island Railroad in Bay Ridge, Brooklyn, including cost of a connection with the Stapleton Piers and with the proposed Brooklyn waterfront industrial railroad, say.....	51,000,000 00
Cost complete of elevated industrial railroad along the Brooklyn waterfront from Bay Ridge to Newtown Creek, say.....	25,000,000 00
Cost complete of a link between the New York Central and the New York, New Haven & Hartford Railroads, with all connections, say	23,000,000 00
Total cost of project.....	\$141,000,000 00

Estimated cost in 1918 for moving freight on trunk line railroads to and from points between the New Haven Yard and Haworth, N. J., including fixed and operating charges.....	\$19,000,000 00
Estimated cost of moving the same volume of freight to and from points between the same terminals, including fixed and operating charges, under the plan now proposed.....	14,000,000 00
Average estimated cost, on the basis of 1918 prices, per car moved to and from points between the New Haven Yard and Haworth, N. J., including fixed and operating charges.....	10 55
Average estimated cost, on same basis, per car moved to and from points between the New Haven Yard and Haworth, N. J., under proposed plan, including fixed and operating charges	7 77
Average estimated cost, on the basis of 1918 prices, per ton of freight moved to and from points between the New Haven Yard and Haworth, N. J., including fixed and operating charges	0 85
Average estimated cost, on same basis, per ton of freight moved to and from points between the New Haven Yard and Haworth, N. J., under proposed plan, including fixed and operating charges	0 63



From aerial survey

STATEN ISLAND WATERFRONT, SHOWING RECENTLY COMPLETED MUNICIPAL PIERS AT STAPLETON

(None of the tonnage from these piers is included in the estimates presented in this report)

These estimates are based on the movement of every character of freight, including merchandise, food supplies, coal, building materials, etc., and on the use of the belt line railroad for only a fractional part of the total freight brought into and through the city. It is also evident that the project lends itself to a much more extensive use, and that with the increased tonnage to be expected there would be a consequent reduction in the fixed charges, with the result of further decreasing the estimated costs under the proposed plan.

While only general reference is made in the analysis to the possible use of the proposed Belt Line Railroad for passenger service, its adaptability to such use for trunk line traffic entering or passing through the Metropolitan District is evident.

To meet the local traffic needs of Staten Island, it is expected that the City will at once proceed with the construction of a tunnel to connect into the Fourth Avenue Subway, in the Borough of Brooklyn, with a position immediately adjoining the proposed Trunk Line Freight and Passenger Tunnel. At the Staten Island terminal, connections with the Staten Island Rapid Transit Railway and the Staten Island Railway are proposed, thereby providing long-deferred rapid transit facilities for the entire Borough.

If the Trunk Line Railroads can reach a decision in favor of the construction of a connecting belt at a sufficiently early date to permit of the entire project being carried out at one time, an undoubted saving in cost could be effected as compared with the conduct of the work as two separate enterprises, and in this case it would, of course, be understood that the final location and design of the Tunnel would be made the subject of discussion between the City and the operators.

Respectfully submitted,

ARTHUR S. TUTTLE,
Chief Engineer.

WILLIAM J. WILGUS
165 Broadway, New York

October 13, 1921.

Mr. ARTHUR S. TUTTLE,
Chief Engineer, Board of Estimate and Apportionment,
Municipal Building, New York, N. Y.

Dear Mr. TUTTLE:

In accordance with your request I am placing before you, in the accompanying initial study, my views on the subject of an outer or Metropolitan belt-line railway, of which the proposed Brooklyn-Richmond municipal tunnel would form a link for the purpose of bringing all the trunk lines that serve the port in intimate contact with every borough of this city.

From this preliminary study it is apparent that a project of this kind may be made self-supporting and, at the same time, bring to the nation, the local communities and the carriers, great advantages, from the lack of which the port is now suffering.

As evidence of what has been done elsewhere to increase efficiency and foster the growth of trade and industry through the creation of belt railways, there is annexed at the end of the accompanying study, extracts from reports bearing on this question for Chicago, Philadelphia, Baltimore, St. Louis, New Orleans, San Francisco and Montreal. All of these reports unite in forcefully endorsing the belt line feature.

In conclusion I venture to express the earnest hope that in their consideration of this project the City and the railroads will find ways of overcoming the many obstacles to be expected in a project of such magnitude, and reach an agreement under which the tunnel may be built in a manner that will best serve this great port and the country at large.

Very truly yours,

WILLIAM J. WILGUS,
Consulting Engineer.

INITIAL STUDY FOR A METROPOLITAN BELT LINE IN CONNECTION WITH THE PROPOSED BROOKLYN- RICHMOND TUNNEL

The purpose of this study is to determine whether or not the creation of an outer belt line for the Metropolitan District is worthy of serious consideration, in connection with the planning of the municipal Brooklyn-Richmond tunnel under the provisions of Chapter 700 of the Laws of 1921 of the State of New York.

It is not claimed that the figures herein given are above criticism. They are founded on the inadequate data furnished by the Port Authority, on the records of individual trunk lines at this port, on United States geological contour maps, and in part on assumptions drawn from experiences elsewhere. However, they are believed to be sufficiently close to warrant the conclusion that the tunnel should be located with reference to a project of this kind, in order that it may serve the purposes mentioned in the Act.

Origin and Volume of Freight Traffic

These are shown in detail on Exhibits A and B and are based on information given by the Port Authority.

It appears that in 1914 the tonnages handled between the New Jersey railroads and Long Island were as follows:

	Tons
Lightered to and from the Long Island waterfront,.....	8,493,000
Floated to and from the Long Island waterfront:	
	Tons
To the Long Island Railroad.....	9,140,000
Other destinations	3,207,000
	<hr/> 12,347,000
Total	20,840,000

To these tonnages should be added the interchanges in New Jersey, aggregating 5,844,000 tons when counted for all of the lines or one-half that, or 2,922,000 tons, when applied to one means of inter-connection.

Assuming that the average annual rate of increase of this traffic is approximately 2% and that the new facilities will be ready for use in 1926, the total increase for the twelve years would be about 25%. It may also be assumed that only one-half of the lightered freight would be handled by rail. On these bases the anticipated rail tonnages for 1926 have been taken as follows:

	Tons
Between New Jersey and Long Island:	
To and from Long Island Railroad.....	11,000,000
To and from Brooklyn and Queens waterfront.....	9,000,000
	<hr/> 20,000,000
Total	20,000,000
Interchanges in New Jersey (no increase assumed).....	2,500,000
	<hr/> 22,500,000
Grand Total	22,500,000

Nothing is here included for the recently completed Stapleton piers.

Proposed Location

The proposed location and profile of the entire project is illustrated on Exhibit H. From this it will be seen that it is proposed to encircle the Metropolitan District west of the Hudson River, from the West Shore Railroad at Haworth on the north, via Paterson, the Passaic River, Short Hills-Summit, Scotch Plains and Metuchen to Perth Amboy on the south.

Crossing Arthur Kill on a high level viaduct with a clearance sufficient for masted vessels, the line bisects Staten Island from south to north for its entire length and connects with the proposed tunnel at Clove Street. From this point the line descends on a 1% and 2% grade to the pierhead line at Arrietta Street, Tompkinsville, connecting en route with the existing Staten Island Rapid Transit Railway for access to the Stapleton piers and for passenger purposes; thence it passes beneath Upper Bay to Bay Ridge, Brooklyn; and thence rises on a 2% grade to connections (a) with the Long Island Railroad, over which access would be had to the Jamaica Bay development, to points in Brooklyn, Queens and elsewhere in Long Island and to The Bronx and New England, and (b) with the proposed Brooklyn Waterfront Railroad on either First or Second Avenue.

In this manner all railroads in New Jersey are brought directly in contact with each other outside of the existing congested and high-priced areas; likewise they are brought in direct rail contact with the railroads that serve Long Island and New England and with the Brooklyn waterfront. Moreover, opportunities are offered for future industrial developments in the sparsely settled areas touched by the new line in New Jersey and along the east bank of Arthur Kill on Staten Island, and for serving the new City piers at Stapleton and the projected great port development at Jamaica Bay.

It is proposed to bring the trains of connecting lines into a new yard in Richmond, and with this in mind gradients on the proposed belt have been made so light that this course may be followed without the need for breaking up trains at the junction points or using pushers.

It has been said that the placing of a belt line outside of the existing "break-up" yards will necessitate new yards at the junctions, but this would not appear to be the case if suitable classifications are made at divisional yards to the west where solid trains for Long Island would be dispatched on the same principle now employed on the Lenigh Valley Railroad in connection with a splitting of traffic at South Plainfield, the New York Central at Spuyten Duyvil, and the Erie Railroad at North Paterson.

East of the Richmond yard the use of electric traction makes possible much steeper gradients, as for instance 2%, as is shown in the following examples of similar operation:

	Ruling Gradient	Train Loads	No. and Wt. of Locos.
C. M. & St. P. Ry.....	2.0%	2,800 tons	2—282 tons
N. & W. R. R.....	2.0%	3,250 tons	2—284 tons
Grand Trunk Ry.....	2.0%	1,000 tons	2— 66 tons
Gt. Northern Ry.....	2.2%	1,500 tons	3—115 tons
M. C. R. R.....	1.5% & 2.0%	1,800 tons	2—100 tons

In fact the train load may be made as great as may be found to be practicable from an operating standpoint, provided the adopted electric locomotives are sufficiently powerful.

It is provided that crossings of both highways and railroads shall be either over or under, thus avoiding all grade crossings, and that the double track main line in every way shall be built according to the most approved practice.

The location shown on Staten Island and under the Upper Bay at the entrance to the Narrows, has been tentatively selected for the following reasons:

1. It effectively serves the entire length of the island rather than a small section.

2. It lends itself to a yard location that has the outstanding advantages of (a) economy of construction by reason of comparatively light grading and good foundations, (b) economy of operation because of a long level stretch beyond the yard in both directions, a moderate 0.5% gradient against steam traction westbound loads from the yard to the crossing of Arthur Kill, and short switching runs to and from Stapleton piers and objectives in Brooklyn, (c) accessorial overhead viaduct for vehicles and pedestrians, (d) harmonizing with the future character of the proposed industrial development on the neighboring westerly side of the island and (e) protection from sea attack in case of war.

3. It is out of sight in tunnel or in walled depression through the residential part of the island north of the yard and therefore unobjectionable.

4. It is ideal for the employment of the trench method of subaqueous tunnel construction because of remoteness from ship movements at Quarantine, comparatively moderate currents and depths of water, non-interference with navigation to a marked degree, and accessibility in connection with the securing and delivering of the raw materials of construction. This method has the advantages of (a) economy of construction through use of machinery and cheap raw materials, (b) economy of operation through lessened depth of track for the predominant eastbound loaded train movement, and through use of a sanitary permanent type of concrete track con-

struction, (c) safety of construction methods as bearing on life and health of workmen, and (d) saving of time of construction with consequent reduction of interest charges and hastening of completion of the project.

5. It admirably lends itself to future rail connections with the New Jersey waterfront at Constable Hook and with the projected island in the Upper Bay.

6. It serves, for passenger purposes, the portion of the island that is now most densely settled and, through trackage or other proper agreement with the Staten Island Rapid Transit Railway, or otherwise, may be made to serve the more sparsely settled sections of the island as well as the industrial region along Arthur Kill.

7. It offers little likelihood of opposition from property owners in Brooklyn.

8. It minimizes the possibility of interference with future additional water-main crossings of the Narrows.

9. It obviates the necessity of negotiating with companies holding existing franchises for rights in connection with the main freight project.

The section selected for the subaqueous tunnel is similar to that of the Detroit River tunnel of the Michigan Central and Canada Southern railroads, with an overhead clearance of 18 feet at the crown, and the land-tunnel section is designed in harmony therewith.

Financial Feasibility

As indicated on Exhibit C, the cost in 1918 of handling the assumed volume of traffic between the New Jersey railroads and between them and Long Island points was \$9.50 per car, or \$19,000,000.

By the proposed new line, as shown on Exhibit D the cost of handling the same traffic, under conditions that existed during the same period, is estimated at \$3.75 per car, or \$6,750,000.

The difference represents the annual savings in operation that would result from the adoption of the new all rail route, viz., \$12,250,000.

From this is to be deducted fixed charges on the estimated cost of the project, all as shown in detail on Exhibit E, viz., \$7,250,000.

Therefore, the net annual saving, after having provided for increased fixed charges is \$5,000,000.

It may be said that against this sum should be offset the fixed charges on the existing facilities east of the west ends of the break-up yards, which will no longer be used for the traffic diverted to the new route, but to this may be replied that such facilities are required and will be utilized for

the growth of business that will continue to obtain at and near the water-front thus relieved of a cross-water movement. In any event the project is shown to be a self-supporting one, coupled with which are the compelling advantages hereinafter set forth.

Impracticability of Inner Belt

The impracticability of the inner belt for heavy traffic of the kind herein shown is demonstrated by the required frequency of train movement, fifteen minutes apart under maximum conditions, as shown on Exhibit D. This would not be permissible through territory which is not only now congested but will become more so when contemplated developments are completed, as for instance the new Newark port, the Hackensack River lumber terminal, Cunard Line piers, Claremont terminal, et cetera.

Then too, the existing drawbridges would be fatal to a traffic of such density.

Additional Advantages of Proposed Belt Line

There are other outstanding advantages that would follow the creation of the proposed belt line, other than the estimated saving in cost of service, viz.:

1. *Military protection in time of war*, of which there is a startling instance in the case of the outer belt line at Paris during the World War (see Railway Age Gazette, Dec. 8, 1916, page 1053). The existence of such a coordinating feature may some day save our national existence.

2. *Improvement of service*, through elimination of gross delays and wasteful expenses to which manufacturers and merchants are now subjected, thereby strengthening the position of this community and the railroads that serve it, in competition with other ports and with rival routes, as for instance the projected Great Lakes-St. Lawrence project.

3. *Development of dormant areas* on the outskirts of the Metropolitan District, to the manifest advantage of the communities affected and the carriers, including New Jersey, Staten Island, Jamaica Bay, Flushing Bay, Hunts Point, Harlem River and elsewhere.

4. *Improved inter-relations of constituent communities*, as for instance Paterson and Brooklyn, etc.; also improved access between all of the inland communities and future water developments on Staten Island and at Jamaica Bay, Flushing Bay, etc.

5. *Unifying of terminal service* of the ten trunk lines that serve the port in such manner as to give them and the public the

inestimable advantages above set forth, accompanied by the further advantages of combined credit and use of equipment and equal opportunities for all in sharing in the expansion of the greatest city in the world. This may be effected through a public agency like the City of New York, as has been done at New Orleans, San Francisco and Montreal, or through a joint agency as in the cases of the Belt Railway of Chicago and the Terminal Railway Association of St. Louis. The latter appeals to the writer as being the most practicable in this instance. Brief descriptions of the principal belt railways in this country and Canada are given in Exhibit I.

6. *Freedom from harbor interruptions* caused by fogs, storms, high tides, ice and marine strikes.

7. *Work for unemployed labor and capital* on a necessary project.

8. *Transformation of New York* from an island to a mainland city.

Passenger Facilities

On Exhibits F, G and H are indicated possibilities in the way of passenger routes which will bring all the New Jersey railroads in connection with the Fourth Avenue rapid transit subway in Brooklyn. Means are also indicated for connecting both shores of Staten Island with the other boroughs of the City and with the trunk lines. Provision for a separate two-track tunnel for local passenger service is not included in this study.

Summary

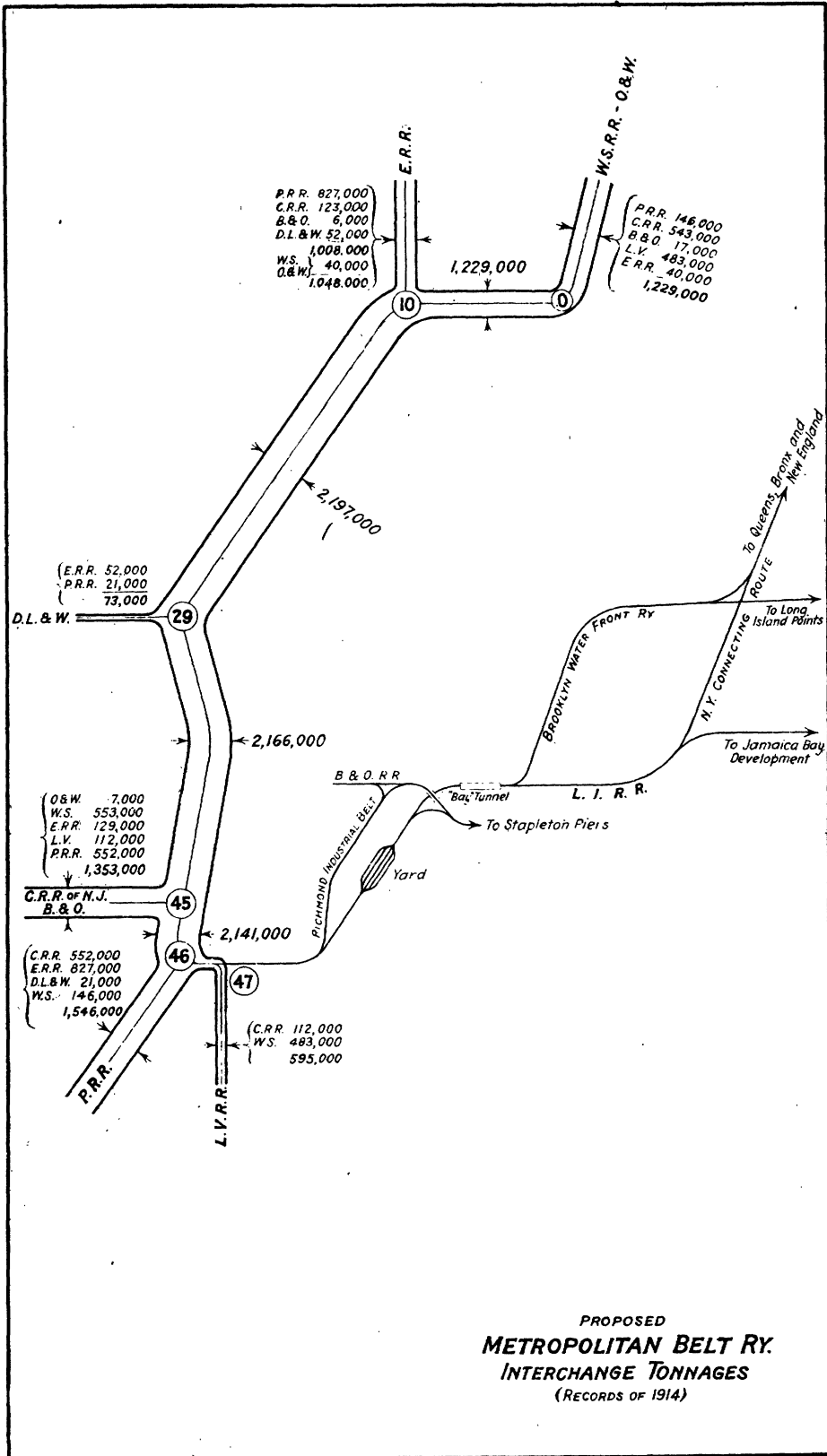
This initial study indicates not only the wisdom of locating the proposed municipal passenger and freight tunnel in such manner as to serve the far-reaching purpose here outlined, but it also points to the wisdom on the part of the railroads of cooperating whole-heartedly with the City to make a success of a project that means so much for the nation, for the local communities, and for the carriers.

WILLIAM J. WILGUS,
Consulting Engineer.

October 11, 1921.

Concurred in by:

JOHN F. SULLIVAN,
Consulting Engineer.



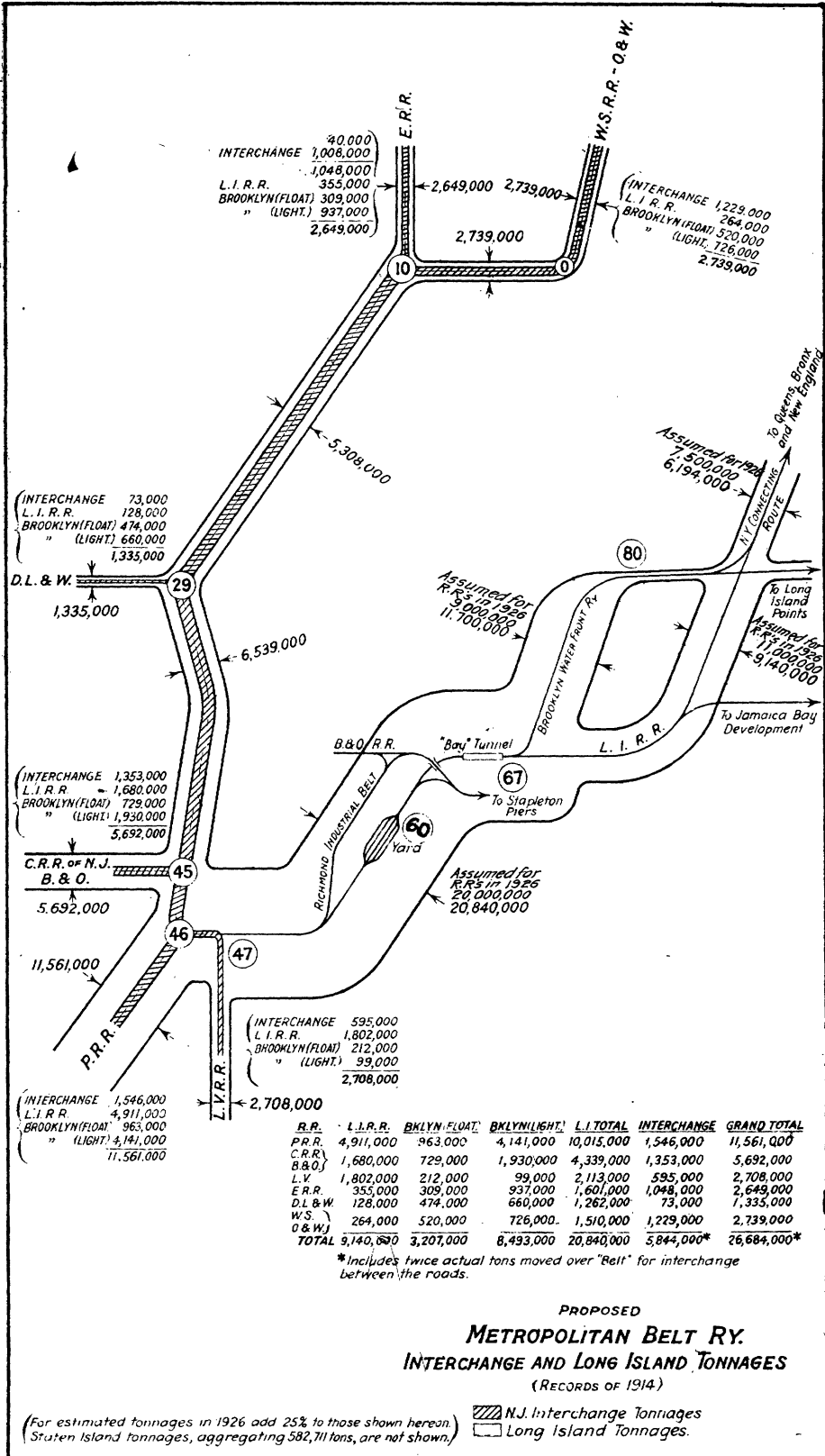


EXHIBIT "C."

OPERATING COSTS

EXISTING METHODS
(Rough Estimates)

Road Haul, Proposed Belt Line Crossings to Break-up Yards:

Railroad	Distance Miles	Interchange		Long Island		Total	
		Tons	Ton Miles	Tons	Ton Miles	Tons	Ton Miles
W. S. R. R.	13.5	1,229,000	16,591,500	1,510,000	20,385,000	2,739,000	36,976,500
E. R. R.	16.0	1,048,000	16,768,000	1,601,000	25,616,000	2,649,000	42,384,000
D. L. & W.	17.0	73,000	1,241,000	1,262,000	21,454,000	1,335,000	22,695,000
C. R. R. N. J.	21.0	1,353,000	28,413,000	4,339,000	91,119,000	5,692,000	119,532,000
P. R. R.	15.0	1,546,000	23,190,000	10,015,000	150,225,000	11,561,000	173,415,000
L. V. R. R.	17.0	595,000	10,115,000	2,113,000	35,921,000	2,708,000	46,036,000
Total	16.5±	5,844,000	96,318,500	20,840,000	344,720,000	26,684,000	441,038,500
Say		5,500,000	90,750,000	20,000,000	330,000,000	25,500,000	420,750,000
Estimated Cost at \$.0036 T. M.*..			\$326,700.		\$1,188,000.		\$1,514,700.
						Say	\$1,500,000.

ALL COSTS

Location	Number of Cars	Costs					
		Operation		Fixed Charges		Total	
		Per Car	Amount	Per Car	Amount	Per Car	Amount
1. Road Haul—Proposed Belt Line							
N. J. Int.	400,000						
L. I.	1,600,000						
Crossings to Break-up Yards	2,000,000	\$0.75	\$1,500,000.			\$0.75	\$1,500,000.
2. Break-up Yards	2,000,000	0.89	1,780,000.	\$0.22	\$440,000.	1.11	2,220,000.
3. Road Haul—Break-up Yards							
to Waterfront Yards	2,000,000	0.66	1,320,000.	0.31	620,000.	0.97	1,940,000.
4. Waterfront Yards	1,600,000	1.60	2,560,000.	0.98	1,568,000.	2.58	4,128,000.
5. Lightering (5,000,000 tons) ...			3,750,000.		1,250,000.		5,000,000.
6. Floating	1,200,000	2.07	2,484,000.	0.32	384,000.	2.39	2,868,000.
	2,000,000	\$6.70	\$13,394,000.	\$2.13	\$4,262,000.	\$8.83	\$17,656,000.
Excess car per diem on 1,600,000 cars (¾ day per car)						\$7.75	1,200,000.
Car Maintenance (running repairs only between break-up yards and waterfront, comparable with similar item included in study for "Belt" railway)							103,000.
Total							\$18,959,000.
Average Cost per Car (2,000,000 cars via present routes) Say						\$9.50	
Average Cost per Car (1,800,000 cars via proposed Belt Line) . Say						\$10.55	
*Same as for proposed "Belt," viz., M.E.			\$736,000.				
C.T.			1,107,000.				
							\$1,843,000. ÷ 518,200,000 T. M. = \$.0036 per T. M.

EXHIBIT "D."

OPERATING COSTS

PROPOSED METROPOLITAN BELT LINE
(Rough Estimates)

	No. Cars	Per Car	Amount
Steam Section—West Shore R. R. to Richmond Yard	1,800,000	\$2.50	\$4,500,000
Electric Section—Richmond Yard to Bay Ridge.....	1,620,000	0.65	1,050,000
Electric Section—Bay Ridge to Brooklyn Waterfront	726,000	1.57	1,140,000
	1,800,000	\$3.72±	\$6,690,000
Say		\$3.75	\$6,750,000
Average Haul—			
	Tons	Ton Miles	Average haul, Miles
W. S. R. R.—Richmond Yard.....	22,500,000	518,200,000	23
Richmond Yard—Bay Ridge.....	20,000,000	160,000,000	8
Brooklyn Waterfront	9,000,000	45,000,000	5
	22,500,000	723,200,000	32

OPERATING COSTS

STEAM SECTION

(Rough Estimates)

West Shore R. R.—Richmond Yard

Between	Character	Dist. Miles	Units			Mileages		
			Tons	Frt.	Cars* Trains†	Frt. Ton Miles	Car Miles	Train Miles
W. S. & E. R. R.	Interchange	10	1,200,000	97,000	2,160	12,000,000	970,000	21,600
	Long Island	10	1,500,000	121,000	2,690	15,000,000	1,210,000	26,900
	Total.....	10	2,700,000	218,000	4,850	27,000,000	2,180,000	48,500
E. R. R. & D. L. & W.	Interchange	19	2,200,000	177,000	3,940	41,800,000	3,363,000	74,860
	Long Island	19	3,100,000	250,000	5,550	58,900,000	4,750,000	105,450
	Total.....	19	5,300,000	427,000	9,490	100,700,000	8,113,000	180,310
D. L. & W. & { CRR PRR LV	Interchange	17	2,200,000	177,000	3,940	37,400,000	3,009,000	66,980
	Long Island	17	4,300,000	347,000	7,710	73,100,000	5,899,000	131,070
	Total.....	17	6,500,000	524,000	11,650	110,500,000	8,908,000	198,050
PRR & Richmond	Long Island	14	20,000,000	1,620,000	36,000	280,000,000	22,680,000	504,000
Grand Total—	Interchange	60	.....	.....	.....	91,200,000	7,342,000	163,440
	Long Island	60	.....	.....	.....	427,000,000	34,539,000	767,420
	Total.....	60	.....	.....	.....	518,200,000	41,881,000	930,860

Annual Operating Expenses

Description	Quantity	Unit	Price	Amount
M. of W.—				
Main track	145	Miles	\$6,000.00	\$870,000.00
Sidings	70	Miles	4,000.00	280,000.00
				\$1,150,000.00
M. of E.—				
Locomotives	930,000	Loco. Miles	.34	\$316,000.00
Cars (running repairs only).....	42,000,000	Car Miles	.01	420,000.00
				\$736,000.00
Transportation—				
Locomotive wages	930,000	Train Miles	.18	
Train wages	930,000	Train Miles	.24	
Other locomotive and train expenses.....	930,000	Train Miles	.12	
Coal	930,000	Train Miles	.50	
Locomotive rent	930,000	Train Miles	.15	
Total road haul.....	930,000	Train Miles	\$1.19	\$1,107,000.00
Yard switching	1,600,000	Cars	0.70	1,120,000.00
Miscellaneous				200,000.00
				\$2,427,000.00
General Expenses				\$200,000.00
Total				\$4,513,000.00
Per train mile				\$4.85
Per car mile				0.11
Per ton mile				0.009
Per car (1,800,000)				2.50

* Average loading = 21 tons per loaded car; 12.4 tons all cars.

† Average train = 45 cars.

OPERATING COSTS
ELECTRIC SECTION
Richmond Yard—Bay Ridge
(Rough Estimates)

	East-bound (All Loads)	West-bound (Loads and Empties)	Total
Gradients:**			
Level	0.0—4.5 miles	0.0—4.5 miles	.....
Descending	1.0—2.5 miles	2.0—1.0 miles	.....
Ascending	2.0—1.0 miles	1.0—2.5 miles	.....
	8.0 miles	8.0 miles	
Tonnages:*			
Freight (contents)	17,000,000	3,000,000	20,000,000
Cars (tare)	15,400,000	15,400,000	30,800,000
	32,400,000	18,400,000	50,800,000
Locomotives (200T. ea.)	3,600,000	3,600,000	7,200,000
Total	36,000,000	22,000,000	58,000,000
No. Cars (av. 21 tons per loaded car*)	810,000	810,000	1,620,000
No. Trains:†			
Annually	18,000	18,000	36,000
Daily—Max. (av. = .75 max.)	66	66	.....
Hourly—Max. (av. = .70 max.)	4	4	.....
Time apart—minimum	15 minutes	15 minutes	.....
Train Loads—Tons:			
Freight (21T. per car)	945	168	.....
Cars (19T. per car)	855	855	.....
Trailing load	1,800**	1,023	.....
Locomotives (2)	200	200	.....
Total	2,000	1,223	.....
Ton-miles:			
Freight (contents)	136,000,000	24,000,000	160,000,000
Cars (tare)	123,200,000	123,200,000	246,400,000
Trailing load	259,200,000	147,200,000	406,400,000
Locomotives	28,800,000	28,800,000	57,600,000
Total	288,000,000	176,000,000	464,000,000
Resistance—Lbs.:			
Level (10 lbs. per ton)	1,620,000,000	990,000,000	2,610,000,000
Ascending (30 lbs. per ton) .....	.....	1,650,000,000	1,650,000,000
Ascending (50 lbs. per ton)	1,800,000,000	.....	1,800,000,000
Total	3,420,000,000	2,640,000,000	6,060,000,000
K. W. H. (53.9 W. H. per T.M.; includes lighting, pumping, etc.)			25,000,000
Car Miles	6,500,000	6,500,000	13,000,000
Locomotive Miles	300,000	300,000	600,000
Train Miles	150,000	150,000	300,000

* Total tonnage is taken from the records of the late Port and Harbor Commission. Average weights of contents per loaded car (21 tons) and of empty car (19 tons); also the ratio of E. B. to total tonnage (85%) is taken from the records of one of the trunk lines terminating at New York.

† Average = 45 cars per train.

** Examples elsewhere are:—

	Tons	Cars	Max. Gradient	Wt. Loco.
C. M. St. P. Ry.	2,800	60	2.0	2—284
N. & W. R. R.	3,250	80	2.0	2—284
G. N. Ry.	1,500	..	2.2	3—115
M. C. R. R.	1,800	45	2.0	2—100
G. T. Ry.	1,000	26	2.0	2— 66

ANNUAL OPERATING EXPENSES

Description	Quantity	Unit	Price	Amount
M. of W—				
Sidings	12 miles		\$4,000.00	\$48,000
Main Track	18 miles		6,000.00	108,000
				<u>\$156,000</u>
M. of E.—				
Cars (running repairs only)	13,000,000 Car miles ..		401	\$130,000
Locomotives	600,000 Loco. miles..		.10	60,000
				<u>\$190,000</u>
Transportation—				
Loco. wages	600,000 Loco. miles..		.18	\$108,000
Train wages	300,000 Train miles..		.24	72,000
Electricity	25,000,000 K. W. H....		.01½	375,000
Other Loco. and Train expenses..	300,000 Train miles..		.12	36,000
Sub-stations				30,000
Miscellaneous				30,000
				<u>\$651,000</u>
General Expenses				<u>\$50,000</u>
Total				<u>\$1,047,000</u>
Per Train mile				\$3.49
Per Car mile .....				.08
Per Ton mile (freight) .....				.0065
Per Car .....				.65

OPERATING COSTS

ELECTRIC SECTION

Bay Ridge—Brooklyn Water Front
(Rough Estimates)

	1914	1926		
		1914+25%	Belt Line Traffic	
Tons—Car floats	3,200,000	4,000,000	4,000,000	
Lighters	8,500,000	10,600,000	5,000,000	
	<u>11,700,000</u>	<u>14,600,000</u>	<u>9,000,000</u>	9,000,000
Cars (assumed average load 12.4 tons)				726,000
Trains (assumed average load, 45 cars)				16,100
Freight ton miles (assumed average haul, 5 miles)				45,000,000
Car miles				3,600,000
Train miles				80,000

ANNUAL OPERATING EXPENSES

Description	Quantity	Unit	Price	Amount
M of W.—				
Main track	28	Miles	\$6,000.00	\$168,000
Sidings	50	Miles	4,000.00	200,000
				<u>\$368,000</u>
M. of E.—				
Road locos.	80,000	Loco. miles..	.10	\$8,000
Cars	3,600,000	Car miles..	.01	36,000
				<u>\$44,000</u>
Transportation—				
Various items	80,000	Train miles..	1.20	\$96,000
Switching, incl. switching loco. repairs	726,000	Cars .....	.80	581,000
				<u>\$677,000</u>
General expenses				\$50,000
Total				<u>\$1,139,000</u>
Per car				\$1.57

EXHIBIT "E."

ROUGHLY ESTIMATED COSTS OF CONSTRUCTION

(Exclusive of connections to Stapleton Piers and Jamaica Bay)

West Shore R. R. (Haworth) to Richmond Yard (double-track main line):

Right of Way—60 miles at \$83,333.....	\$5,000,000	
Grading—8,100,000 c. y. at 60c.....	4,860,000	
Tunnel (including lining), 1.3 miles at \$2,000,000.....	2,600,000	
Masonry—120,000 c. y. at \$11.....	1,320,000	
Steel—112,500 tons at \$90.....	10,125,000	
Track and Accessories, including signals, etc.....	4,720,000	
Buildings, water and fuel stations, etc.....	750,000	
Equipment, exclusive of through road power assumed to be furnished by connecting lines and allowance made therefor in operating costs.....	2,870,000	
Overhead percentages, including engineering, general expenditures, contingencies and interest during construction, 30%, say.....	9,755,000	\$42,000,000

Richmond Yard to Bay Ridge, Brooklyn (two-track tunnel):

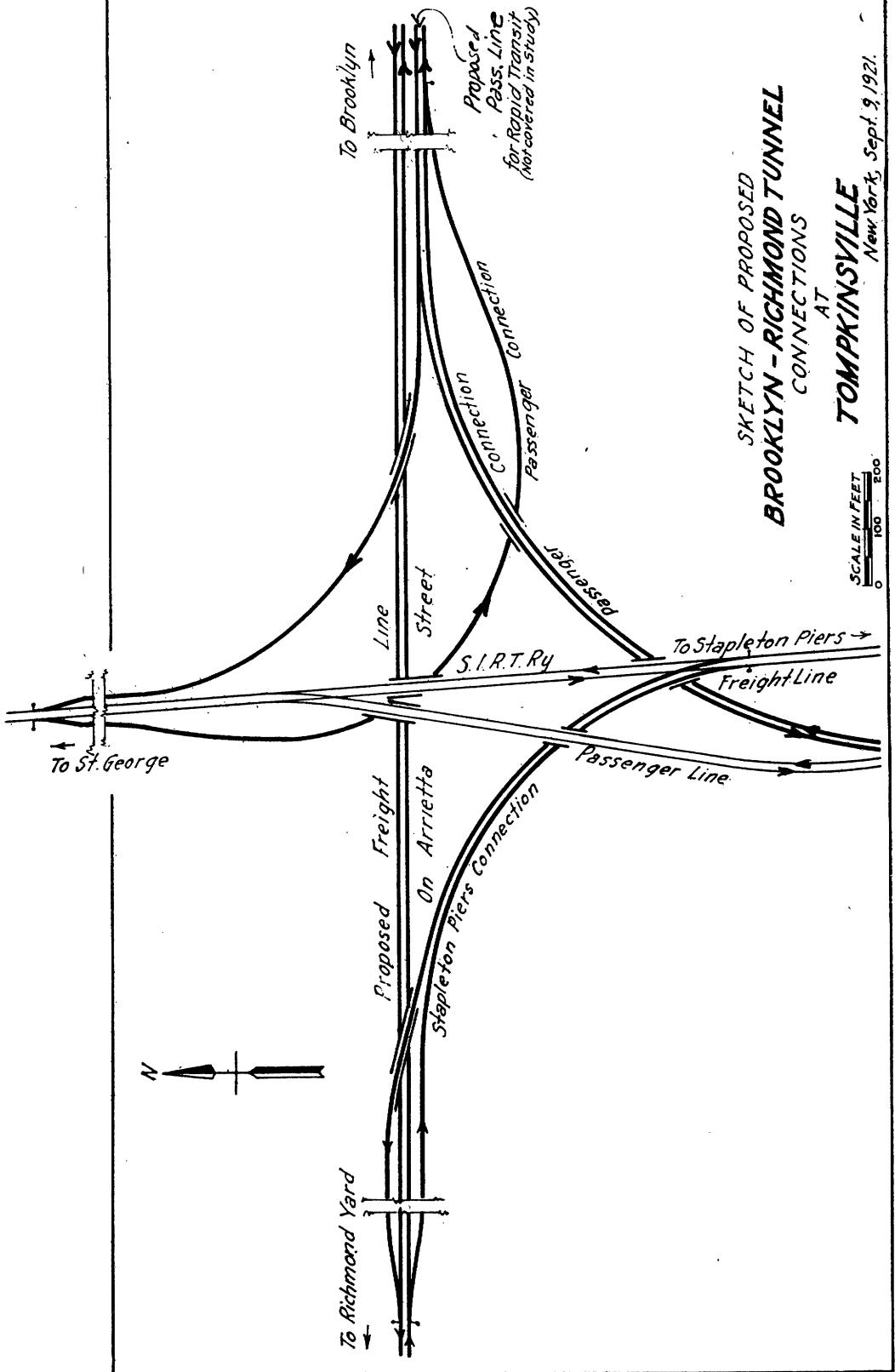
(Based on figures taken from estimate of Jesse B. Snow, Tunnel Engineer, excluding Stapleton connection but including electric locomotives)	51,000,000
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Brooklyn Waterfront Railway (double-track main line):

(Rough estimate by John F. Sullivan, Consulting Engineer)	25,000,000
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Total estimated cost.....	\$118,000,000
Annual fixed charges at same interest rate adopted by Port and Harbor Commission, 5%, plus 2% for taxes on investment exterior to New York, plus 1% for amortization of investment in N. Y., an average of say 6% (this rate used for comparative purposes only), say.....	7,250,000
Average per car (1,800,000), say.....	4.00

NOTE—These figures are believed to be ultra-conservative. With careful planning based on field surveys, better knowledge of sub-surface and other local conditions and a falling market the actual cost should be far less.



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EXHIBIT "I"—BELT RAILWAYS

Extracts from Report of the Terminal Commission on Terminal Facilities of the Commonwealth of Massachusetts, April 1, 1916, except where otherwise noted.

General

* * * It was found by the Commission that at all of the larger cities of the United States belt lines are either in operation or are contemplated, and that the ablest traffic men in this and other countries agree that belt lines are great aids to the commercial, industrial and railroad development of a city. * * *

Chicago

In Chicago, which is the greatest railroad center in the world, the Commission found five belt lines in operation. City and railroad officials and traffic experts told the members of the Commission that without these belt lines the railroads of Chicago could not efficiently handle the tremendous volume of business which converges at that point. One of these belt roads, the Belt Railway of Chicago, serves as the principal medium of interchange of carload freight at that city. This road operates a monster clearing yard that has a capacity of 10,000 cars a day. The charges of this road amount to \$6 a car when freight originates with the belt company, and about \$4.50 a car where the belt company acts as intermediary. The railroads enjoying the road haul absorb these charges.

Without going into the functions of all the belt roads at Chicago, it might be well to mention that another of these roads, the Chicago Junction Railway, operates universal freight stations, where freight for any of the railroads serving Chicago may be left. This company will sort freight left at its stations and deliver it to the railroads that are to haul it. The charge for this service is \$1 per ton. The railroads absorb the charge and the shipper gets the flat Chicago rate. This sort of thing is unknown in Boston. In Chicago, where the shipper has a siding, the belt company takes his less than carload shipments direct from the siding and forwards them for the flat Chicago rate. If the shipper has not a siding, he teams his freight to the nearest universal receiving station and his shipments are unloaded there. But one door need be visited. He gets the flat Chicago rate, plus, of course, the teaming cost to and from the universal station. * * *

Philadelphia

In Philadelphia, where with a contemplated expenditure of approximately \$25,000,000, the city and railroad officials are jointly engaged in extensive port improvements, the backbone of the development is, according to city officials and officials of business organizations, the Philadelphia Belt Line Railroad.

The Philadelphia Belt Line Railroad, which is a semi-public property, was incorporated in 1891 by a group of public spirited citizens, who were alarmed at the danger of railroad monopoly of the waterfront. A majority of the stock of this road was placed in trust for the city. This stock is voted by trustees, the majority of whom are elected by the principal business organizations of Philadelphia. The road does not do an operating business. It has a charter which permits it to lay its tracks to any portion of the important waterfront of Philadelphia, and it has tracks which extend along about seven miles of this frontage. Through the belt road and its charter, any road in Philadelphia is enabled to gain entrance on an equal basis with other railroads to any portion of the Philadelphia waterfront. The railroads themselves have paid for the greater part of this trackage. They operate the same and pro-rate the expense, charging each other for interchange from \$2 to \$4 a car for a two-way movement.

In connection with the recent agreement between the roads and the city, whereby the terminal improvements which are to cost approximately \$25,000,000 are to be made, the Belt Line principle was endorsed. The agreement included provision for the extensions of the tracks along the waterfront of two of the railroads and also for the extension of the belt line tracks and the application of the belt line principle to the track extensions of the two railroads in question. It is asserted by the city officials of Philadelphia that prior to the establishment of the belt, the railroads virtually divided the city against itself and that the interchange of a freight car was a rarity. They say that the Belt Line has made the railroads more tolerant of each other and easier to deal with. The business organizations of the city of Philadelphia advertise the belt railroad as one of the city's greatest advantages, and state that there is nothing like it on the northern seaboard.

"All of the large piers in the harbor are connected with the tracks of the Pennsylvania Railroad Company, the Philadelphia and Reading Railway Company and the Baltimore & Ohio Railroad Company through the Philadelphia Belt Line Railroad Company, a semi-public corporation. This trackage convenience permits of direct delivery of goods brought from manufacturing plants to the vessels, the Belt Line tracks running into all of the modern piers. The use of the Belt Line, with its direct track connections from pier to vessels, eliminates the costly work of lightering." (Extract from "Port of Philadelphia," November, 1919.)

Baltimore

The city of Baltimore is expending \$2,000,000 on marginal streets and a belt railroad which is intended to connect all of the railroads in the city. While this road is now operated for only about 1¼ miles and at present connects with but one of the three principal railroads, the officials of that

city told the members of the Terminal Commission that the belt and the highway have already done much to develop a section of the city which had remained industrially stagnant for fifty years. The principal marginal street in Baltimore is known as the Key Highway.

"The city is now constructing in the beds of these several streets the Municipal Harbor Railroad, a railroad owned and to be operated by the municipality. The road will connect the three trunk lines which serve the city. * * * Through the building and operating of this Municipal Harbor Railroad by the city, manufacturing and industrial concerns of Baltimore will enjoy the advantage of the flat Baltimore rate and the elimination of high switching charges." (Extract from "Port of Baltimore, 1918.")

St. Louis

Two belt railroads were found by the Commission in St. Louis. Both are operated by the Terminal Railroad Association of that city. This is a regularly incorporated company which does a passenger and freight terminal business, and its stock is held by the fifteen companies which it serves. The association has been in existence upwards of twoscore of years. It does not pay any dividends; its profits are put into equipment when receipts exceed expenses, and any deficit if not made up by future business is pro-rated among the owner companies. The officials of this road told the Commission that between 75 per cent. and 80 per cent. of the freight business of St. Louis is handled by this association and that the tracks of the association belt line extend 25 miles beyond the station. This association does an interchange business between all the railroads and maintains warehouses for the receipt and delivery of less than carload lots, and terminals for the receipt and delivery of carload lots. It also does an interchange business between various industries located along these tracks and those of the railroads. It handled on an average 10,120 freight cars a day in 1914, and a total of 3,693,996 cars for the year.

It was stated by the officials of this association that one of its belt lines was built in 1903 and that at the close of the World's Fair in 1904 there was not a single industry on it. The belt line now has between 35 and 40 industries located on it, and does a business of three hundred cars a day between these industries. It was built on swamp land worth about \$100 an acre; parts of it are now worth \$5,000 an acre, according to the officials of this association. These officials say that the industries have increased the valuation of the city, given employment to many people, and stimulated the growth of the city's business.

New Orleans

In New Orleans, where \$25,000,000 is being expended in the development of the waterfront facilities, the city officials, and officers of the local

traffic association told the members of the Commission that the backbone of the transportation improvements of the City of New Orleans is the public belt railroad which is owned and operated by the city. The waterfront of that city is being developed by a state commission. This development is being accomplished on a broad scale and little is being left undone to make New Orleans one of the great ports of the world; yet the traffic experts of that city publicly declared to members of the Terminal Commission that these extensive waterfront improvements would be of comparatively small value to the city were it not for the fact that the great docks and wharves that have been and are being constructed there are and will be served by a public belt railroad, which will permit all railroads serving New Orleans to obtain access to the New Orleans waterfront on an equal basis and at a minimum expense. The public belt road of New Orleans is under the direction of an unpaid commission of 17 persons, 11 of whom are appointed from the membership of the commercial organizations of the city, and 5 appointed by the mayor from the city at large. The mayor is ex-officio president of the corporation. This road has about 40 miles of track and is to be extended. It has 10 miles of double track along the principal section of the waterfront, where it has exclusive track connection with all of the public wharves. In 1914 it had a net operating surplus of \$63,064.15. The first \$500,000 used for the construction of this road was appropriated from the city treasury. A bond issue of \$2,000,000 was authorized for the construction of the road and about \$1,000,000 of this has been thus far expended. The earnings of the belt line are supposed to pay the interest charges and to pay off the bonds as they come due.

In New Orleans the city officials stated to the Commission that the public belt road which operates its own engines charges but \$2 a car for interchanging. The officials stated that prior to the establishment of the public belt railroad, the railroads of the city "were at each other's throats," as it were, and charged as high as \$20 a car for interchange service.

In addition to affording the railroads prompt and impartial service, the public belt of New Orleans has, according to the officials of that city, attracted industries to the city. City officials say that they are confident that it is destined to become a tremendous factor in the industrial development of their municipality.

"The New Orleans Public Belt Railroad is a terminal switching railroad owned exclusively by the City of New Orleans, and operated and controlled by the said municipality. * * *

"The purpose of the Public Belt Railroad is to supply comprehensive, economical and non-discriminatory switching service to all who require and can use same. It transfers cars from railroads to railroads, from railroads to wharves, from wharves to railroads, from railroads to industries and

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public delivery tracks, from industries to all transportation outlets of the city, and makes available to railroads that desire an entrance into the city, all of the said railroad, wharf and individual switch connections at a low charge." (Extracts from "Facts Regarding the New Orleans Public Belt Railroad," October 15, 1919.)

San Francisco

At San Francisco there is a public belt road in operation. This road, the officials have stated in a letter to the Terminal Commission, is on a paying basis. It is owned and operated by the State under the jurisdiction of the Board of Harbor Commissioners of San Francisco. It was constructed in 1890-92 and its main line is 6.7 miles long, while its spur, industry, and team tracks extend over 19.1 miles. The officials of the Board of Harbor Commissioners stated that the shippers of San Francisco can now send a car from one end of the waterfront to the other for \$5, whereas previously this operation was performed by the railroad companies via barge and cost \$10 and \$15 per car.

There are in all 115 different industries located on the tracks of the San Francisco belt, while other industries not having spur track connections use the belt tracks and pay a cash rental per car per day, according to the officials of the Board of Harbor Commissioners. The latter in communications sent to the Terminal Commission said that undoubtedly many industries located in San Francisco because they were assured of the belt railroad service. The road handled, in 1914, 230 cars a day. In 1913 the belt railroad was extended at the request of the military authorities, through the Fort Mason Military Reservation to serve the United States army transport docks at the north of that reservation. An extension from the transport docks to the Presidio, one of the largest military reservations in the United States, is contemplated. The charges of the belt road run from \$2.50 to \$5 a car.

"By these constructions and extensions, a continuous belt railroad switching system, adequately equipped, is now in full and successful operation around the whole active harbor front of San Francisco, from the United States transport docks on the north and west to Channel Street on the south. It is a tremendous gain to the harbor, and its real advantages only become properly estimated when it is recollected that even such a great seaport as New York has no harbor belt line." (Extract from "Biennial Report of the Board of State Harbor Commissioners," 1916.)

Montreal

At Montreal the only Canadian city visited by the Commission, the same keen understanding of the proper methods to promote the advance-

ment of a city that is evidenced in the more progressive cities of this country, was apparent. The waterfront of this city is under the jurisdiction of a Federal board. The officials of this Federal Commission, after having visited the principal ports of the world, are enthusiastic advocates of the belt railroad. The Montreal public belt road which extends along the harbor front was constructed by the Board of Harbor Commissioners a number of years ago. At first the railroads were allowed to operate it jointly. As a result of the quarreling between the railroads, it was finally decided by the Commission to take over the work of operating this belt road themselves. This venture, the Commissioners stated, has proven a success and the belt railroad has tremendously aided the phenomenal growth of this great port. It is on a paying basis financially.

This road charges \$2.50 a car for interchanging between the ships and the railroads and \$5 a car for interchanging cars between the railroads. Officials say that they can do this work much cheaper than the railroads can do it themselves, and that for the same service which they render the railroads for \$5 a car, the railroads have charged each other as high as \$15 a car.

According to statements of the Montreal harbor officials, not a single complaint regarding the movement of freight has reached the Commissioners since the establishment in 1907 of their traffic department, which operates the terminals. Respecting this, a Montreal official said, "And what this means can be readily appreciated by your Commission, as the efficiency and despatch of a port depends more upon this fact than upon any other. Inefficiency spells congestion in a very short time."

The Harbor Commissioners and railroad officials met by the members of the Terminal Commission were inclined to smile at the terminal facilities of Boston, with which they are familiar. They suggested that Boston could learn much from San Francisco, New Orleans and other American cities, particularly the two former. * * *

In their report for 1915, which has just been issued, the Montreal Harbor Commissioners, than whom there are no more progressive respecting port development, have this to say: "The operation of the railway terminals has proved to be one of the most important and successful features of the development of the Harbor of Montreal."

Respecting the Public Belt Railroad, this same report says: "The rates charged by the Harbour Commissioners for this service are so moderate and the existing facilities and manner of operation give such good despatch that there is an immediate urgent demand by the new industries rapidly springing up along the waterfront for the prolongation of the harbor terminals to new sites and to industrial wharves specially being constructed.

"Probably no feature of harbour development will give such good results to the industrial growth of the city and at the same time to the success of the harbour."

" * * * The development of the harbour during the last twelve years has in view the best possible connection between the Harbour Terminal Railway and the ocean steamship berths. In addition to this, the construction of the High Level Marginal Railway gives close and prompt transfer of cars between one railway and another and connects with the many growing industries along the rapidly developing waterfront. * * * The success of the Montreal Harbour Railway Terminals may best be exemplified by the table showing the mileage and cars handled, for the last ten years. From this table it will be seen that the mileage has about doubled; car handling increased about four times and financial returns nearly five times.

	Mileage of Harbor Rail- way Tracks, Miles.	Number of Cars Handled by Commiss'rs.
1909.....	28.26	75,636
1910.....	28.86	79,466
1911.....	28.97	93,859
1912.....	34.91	112,911
1913.....	37.30	114,531
1914.....	39.88	114,449
1915.....	44.92	157,480
1916.....	49.11	234,439
1917.....	52.35	215,394
1918.....	55.35	247,009

" * * * The Montreal Harbour Railway Terminals consist of surface lines situated between Victoria Bridge and the end of the piers on the south side of the canal; and the Marginal lines from McGill Street down to the Imperial Oil Wharf at Montreal East; having a total trackage of 55.35 miles. * * *

"Much of the success in Montreal Harbour is due to despatch in loading vessels and unloading cars, and effort is made by direction of the Harbour Commissioners for a prompt and efficient service. So successful has this service been that there was not a single complaint, although many might have been expected during the 200 consecutive working days in the Montreal Harbour navigation season."

"The extension of the Harbour Commissioners' Marginal Railway eastward along the river front of the Harbour of Montreal has already resulted in wonderful industrial activity from Hochelaga to Pointe-aux-Trembles. A few years ago the Montreal Cotton Mill was the limit of the industrial development along the waterfront in the eastern part of the City of Montreal. With the development of the harbour and the extension of the High Level Railways and the active operation of the railway terminals, this valuable manufacturing district has entered upon a new era of prosperity. * * *" (Extracts from the "Harbour of Montreal Annual Report, 1918.")

JOHN F. SULLIVAN
233 Broadway, New York

October 14, 1921.

Mr. ARTHUR S. TUTTLE,
Chief Engineer,
Board of Estimate and Apportionment,
Municipal Building,
New York City.

DEAR SIR:—

Pursuant to your request I transmit herewith a report embodying a suggestion for a Manhattan-Bronx Tunnel as a part of the comprehensive Belt Line System which has been under consideration.

Very truly yours,

JOHN F. SULLIVAN,
Consulting Engineer.

GENERAL STATEMENT

The studies that have been made for the proposed Brooklyn-Richmond Tunnel under the provisions of Chapter 700 of the Laws of 1921 have revealed a situation that makes it important that in considering any comprehensive plan for the development of the City and Port of New York that through rail facilities be provided for all of the five Boroughs of the Greater City.

It has been impracticable within the time allotted and the limited information available to make other than a tentative suggestion of a route via which the New York Connecting and New Haven Railroads in The Bronx may be connected with the New York Central Railroad in Manhattan via a tunnel that will be so located as to offer the maximum of advantages with a minimum of objections.

About 13,350,000 tons of freight of New Jersey Railroads was handled for Manhattan and The Bronx exclusive of about 4,850,000 tons to railroad stations south of Sixtieth Street in 1914, but the details of the tonnage, commodities and character of freight business that would be handled by such a connecting line as herein suggested are not as yet available, and though the report of the New York-New Jersey Port and Harbor Development Commission contains some general figures, there were no details available upon which a definite analysis could be made for this section of the City.

The suggestion that a belt-line railroad be constructed in New Jersey to connect with a line to be constructed across Staten Island thence via tunnel to Bay Ridge, Brooklyn, there to connect with the present Long

Island and connecting railroads, emphasizes the importance of having the New York Central connected to such a terminal system as it is contemplated that important developments, such as all rail facilities to the Brooklyn Waterfront and industrial districts, Jamaica Bay, Stapleton Piers, Flushing Bay, Hunts Point, the Municipal Terminal Market in The Bronx and similar facilities and industrial district will require the service flexibility and dispatch of a terminal system jointly operated by all of the railroads of the City and Port, especially if commercial supremacy is to be maintained and the needs of economically handling domestic as well as competitive foreign shipments is to be accomplished.

All rail delivery of freight through the medium of a terminal system will permit of car delivery to given points, from which trucking may be done within given zones, with the result that street congestion and non-productive time of the trucks could be materially reduced.

A tunnel such as is herein proposed in connection with existing rail facilities and the general development that contemplates the connecting up of all of the trunk lines of the City and Port of New York for standard railroad equipment has the advantages of not interfering with the operation of existing facilities during the periods of construction or of any contemplated expansion of passenger facilities, places no restrictions as to the commodities to be handled or class of service and practically eliminates delays in traffic due to weather conditions and other items incidental to the operation of floating equipment for the interchange of freight; furthermore, there will be a material reduction in harbor congestion and a reduction of the necessity of waterfront occupancy by railroads for local terminal facilities.

Proposed Location of Tunnel.

The general location of the proposed tunnel is illustrated on Exhibit No. 4 (by a heavy dotted line) and is presented as the most desirable of several routes studied.

In general there would be a double track tunnel about 3.7 miles in length from connections with the New York Central Line on the Hudson River south of Fort Washington Park; thence easterly under West 168th Street, in Manhattan, under the Harlem River; thence easterly along the line of East 168th Street, East 169th Street, Southern Boulevard and under the present passenger tracks of the New Haven Railroad to about Longwood Avenue, in The Bronx, when the tracks would be so connected as to permit of head-on connection to the connecting railroad over the Hell Gate Bridge, or to the New Haven Yards at Oak Point.

The entire tunnel length may be constructed on satisfactory operating grades and at an elevation that will prevent grade crossings of traffic and a minimum of interference with existing structures and utilities.

A connection on the east side of the Harlem River will provide direct

rail service to the proposed Municipal Terminal Market and permit of the development of a marginal belt line railroad in The Bronx, upon which jointly operated stations could be located at points that would be convenient to existing city bridges, thereby giving both Manhattan and The Bronx the advantage of such facilities.

Exhibits Nos. 1, 2 and 3 illustrate the suggested connections of the proposed tunnel to the New York Central, the Harlem River Belt Line and the New Haven Railroads.

Manhattan-Bronx Tunnel.

Estimated Cost.

Right of Way.....	\$2,000,000 00
Double Track Tunnel and Approaches.....	16,760,000 00
Track Electrification, Signals, etc.....	1,000,000 00
Total	<u>\$19,760,000 00</u>
Engineering-Administration—	
Legal and Contingencies	2,964,000 00
Total Estimate Cost of Tunnel.....	<u>\$22,724,000 00</u>

Summary of Advantages of Proposed Tunnels.

1. The five Boroughs of the Greater City would be linked with the trunk lines of the Port—thereby presenting the opportunity for all of the industries and marine facilities of this territory to be in direct rail communication with the commerce of the Nation.

2. Improvements in time of delivery, car movements, flexibility and ultimate cost of handling shipments.

3. Opportunity to better the methods of distributing food, milk, express and possibly baggage and mail.

4. Of great value in an emergency for use, either of passenger or freight service, in the event of the necessity of temporary diversion of traffic from existing channels.

JOHN F. SULLIVAN,
Consulting Engineer.

Concurred in by
W. J. WILGUS,
Consulting Engineer.

**PRELIMINARY REPORT ON THE LOCATION AND COST OF
THE BROOKLYN-RICHMOND FREIGHT AND
PASSENGER TUNNEL**

CITY OF NEW YORK

BOARD OF ESTIMATE AND APPORTIONMENT

Office of the Chief Engineer

ARTHUR S. TUTTLE,
Chief Engineer.

JESSE B. SNOW,
Tunnel Engineer.

October 14, 1921.

Mr. ARTHUR S. TUTTLE,
Chief Engineer, Board of Estimate and Apportionment,
Municipal Building, New York City.

DEAR SIR:

The following is submitted as a preliminary report on the location and cost of a tunnel for freight and passenger traffic between the Boroughs of Brooklyn and Richmond:

Chapter 700 of the Laws of 1921, Section 1, authorizes and requires that:

“The Board of Estimate and Apportionment of the City of New York shall within two years after the taking effect of this Act begin the construction of a Railroad Tunnel under New York Bay between the Boroughs of Richmond and Brooklyn. Such tunnel shall be used for both freight and passenger purposes. * * * The said Board may select the sites necessary for such tunnel and the terminals thereof * * *.”

It was at once recognized that to carry out the provisions of this Act and best serve the interests of the City of New York, the tunnel must be located so as to provide suitable connections with all of the trunk line railroads entering the Metropolitan District, and also to provide connections with the Staten Island railroads to meet the growing demand of Staten Island for passenger service. It must also provide a connection with the City's piers at Stapleton, and permit future connections with the City's proposed development of Jamaica Bay and with the suggested industrial railroads and other water terminals in the Boroughs of Manhattan, Brooklyn, Queens, The Bronx and Richmond.

Up to the present time our investigations have been largely devoted to the studies of a tunnel for freight purposes only, as it was believed that this question should be given first consideration. If the railroads look upon the proposed tunnel favorably, it will be necessary to construct additional tubes for local passenger traffic, but the location selected is such that in case the railroads should not consider the project favorably, connections

can be made with the Staten Island railroads in Richmond and the Fourth Avenue subway in Brooklyn, and permit the use of the tunnel for passenger service until such time as the railroads feel that their business warrants their consideration of the project.

In the brief time allowed it has been impossible to make any detailed surveys, or to prepare extensive plans. Data obtained by the Transit Commission in its investigation for a tunnel under the Narrows, and by the Board of Water Supply in connection with the construction of the Narrows Siphon were made available by these bodies. Recourse was also had to the anchorage chart of New York Harbor, published by the United States Coast and Geodetic Survey, to the topographic maps of the Borough of Richmond, to right of way maps and profiles of the Staten Island and Long Island Railroads, and to the records of your office.

In Brooklyn and Queens the location of the Long Island Railroad and the New York Connecting Railroad offered opportunities from which all the desired connections on the easterly side of the Narrows could be made.

In Richmond it was found that the Staten Island Rapid Transit Railway, the only available one at present existing on the Island, would be inadequate to handle the expected volume of traffic without very complete reconstruction. Furthermore, this road has no yard suitable for handling the expected volume of traffic. Therefore it will be necessary to build a large classification yard. There are but few sites available for a yard of the size required to handle the estimated volume of traffic, and, at the same time, suitable for connections with the New Jersey trunk line railroads. In investigating possible sites for the classification yard, it was endeavored to obtain sites removed as far as possible from existing or developing residential districts and to obtain locations best suited for industrial or commercial development. With these limitations two principal sites are available, as follows:

1. The district at the foot of the western slope of the Staten Island hills near the centre of the island.
2. The low ground at the head of Richmond Creek near the Village of Richmond.

The first site lies south of the residential area along the north shore and provides a suitable connection for any tunnel line passing directly west from the Narrows through the main range of hills, and also with any railroad entering Staten Island from the west between the B. & O. R. R. bridge on the north and Perth Amboy on the south.

The second site, at the head of Richmond Creek, provides suitable connections for any tunnel line having its portal east of the main range of hills, as well as with railroad lines entering the Island from the west.

MAXIMUM GRADE: In view of the grave objections to steam locomotives in tunnels, and the satisfactory results obtained elsewhere by electric

traction, it is apparent that the latter should be adopted for the operation of this tunnel. With electric traction, the weight and power of the locomotive can be increased almost indefinitely. The selection of the maximum grade, therefore, appears to be influenced chiefly by the strength of existing draft gear in ordinary freight service. In our studies of the various routes, the cost of the tunnel was estimated for both 1 per cent. and 2 per cent. maximum grades, with the result that the latter grade indicated a saving of over \$15,000,000. Still steeper grades, operated with pushers, show very large savings in first cost, and from the purely economic standpoint appear justifiable, even with very heavy traffic. Practical considerations, however, have resulted in the selection of a maximum grade of 2 per cent. for the purposes of this report. This will reduce pusher operation to a minimum, and, furthermore, we have the precedent of the successful electric operation of a number of existing trunk railroads, which handle long and heavy freight trains on grades of 2 per cent. and 2.2 per cent.

MAXIMUM CURVATURE. The maximum curvature for tunnel alignment should be in harmony with existing practice on the Long Island and New York Connecting Railroads, and, with a view to keeping the Tunnel Section as small as possible, it is recommended that a maximum curvature of 3 degrees be adopted.

GOVERNMENT LIMITATIONS. At a conference with the United States District Engineer in whose jurisdiction the Tunnel would be located, it developed that the War Department would permit no permanent structure above a plane 50 feet below mean low water between pierhead lines, and further, even below this plane, the War Department would probably be opposed to any encroachment above the existing river bottom, because of its possible effect upon tidal velocities. In our preliminary studies the top of the tunnel has been located so as to provide a permanent cover of material between it and the river bottom at its lowest point, and it is located at least 10 feet below the dredging plane at all points.

CLEARANCES AND CROSS SECTIONS. The minimum possible interior cross section of tunnel has been determined by a study of the largest types of rolling stock now in use on the railroads entering New York City. This has resulted in the adoption of the sections shown on Plate No. 1.

ROUTES STUDIED

The construction of a tunnel under the Narrows is limited to about two miles of shore front extending in Brooklyn from 67th street on the north to 95th street on the south, and in Staten Island from St. George on the north to the U. S. Government Reservation on the south.

In order to determine the most economical line on which the Narrows could be crossed under the limitations imposed by the U. S. Government as to depth below water at which the permanent structure must be built,

and as to the depth below which a temporary blanket over the tunnel for construction purposes must be kept, a contour map of the bottom of the Narrows was plotted from data given on the anchorage chart of New York Harbor. Eight different crossings, which would terminate at the most advantageous points in Brooklyn and Richmond, were then selected, and profiles of these lines plotted. Variations in the land approaches to these crossings to give the most economical type of land structure led to the study of fifteen routes. Most of these routes were studied for 1 per cent. and 2 per cent. grades in both Brooklyn and Richmond.

It was found that in all cases the cost of the 1% grade lines was so much in excess of the cost of the 2% grade lines that in accordance with the studies outlined above the saving in operating costs on a 1% line did not warrant its adoption. The studies were narrowed down, therefore, to 2% grades, except where existing conditions made it desirable to keep the tracks depressed for such a length that the additional cost of a flatter grade was deemed warranted.

In the laying out of the routes the desirability of long tangents and the minimum amount of curvature was kept constantly in mind, as well as the locations for classification yards.

After estimating the cost of all the lines, the question of alignment was considered in the light of the comparative costs of the different routes. This led to the elimination of twelve of the routes, and thenceforth studies were concentrated upon two northerly routes, one crossing the Narrows from Owls Head Park in Brooklyn to Arrietta Street, in Richmond and the other from Owls Head Park in Brooklyn to Hyatt Street in Richmond, and upon one southerly route crossing from the vicinity of 86th Street in Brooklyn to near Maryland Avenue in Richmond. For these routes, connections to the Stapleton Piers and to the suggested industrial railroad along the Brooklyn waterfront were provided.

Of the two northerly crossings the one at Arrietta Street, in Richmond, was considered highly inadvisable, due to the location of the Catskill Water Supply pipe in this street, as it would necessitate the laying of another water main from Brooklyn before any work could be started on the construction of the tunnel near the Staten Island shore, and further, it would involve a large expense in the restoration of the facilities which the location of the tunnel on this line would destroy. Further, a route practically identical in every respect could be obtained by using the Hyatt Street crossing, but the relative cost of the two lines cannot be accurately determined without a complete set of borings.

The northerly routes offer some advantages for operation beyond the tunnel terminal in Staten Island, but these are believed to be insufficient to overcome the estimated difference in cost of \$9,000,000 between them and the southerly route, so that, for this reason, the southerly route is favored.

ROUTE RECOMMENDED

The route that I recommend extends from the Long Island Railroad, near Sixth Avenue, Brooklyn, under private property and City streets to the bulkhead near the foot of 86th Street; thence under the Narrows to Staten Island, near the foot of Maryland Avenue; thence under private property to a crossing under the State Island Railway between Grasmere and Dongan Hills; thence on a private right of way and parallel with the Staten Island Railway to Grant City; thence curving to the westward and continuing on private right of way to the Classification Yard, located near Richmond, Staten Island. The total length of the above line is about eight and one-half miles. This line, together with a connection to the Stapleton Piers, is shown on Plate No. 1. A connection for a possible future industrial railroad along the Brooklyn waterfront is also indicated on this Plate. The profile of this line is shown on Plate No. 2.

In the short time available for making these studies it has not been possible to investigate thoroughly various methods of building the tunnel under the Narrows. Because of this fact, all of the estimates have been prepared for twin cast-iron tubes 24 feet outside diameter, as shown on Plate 1, built by the shield method under compressed air. This method of construction has been thoroughly tried out in New York City and elsewhere during the past 100 years and has been selected as the best type for all the tunnels heretofore built or now contemplated under the East River and the North River, New York City. It was, therefore, most logical to prepare the estimates upon a basis of construction concerning which the most accurate predictions as to costs, progress and ultimate success could be made.

It is believed that some form of trench construction might materially reduce the cost of the Narrows section of the work, but further careful studies of all local conditions affecting its application to this problem must be made before this method could be decided upon. The effect of the adoption of the trench method on the relative costs of the northerly and southerly routes would be to reduce the cost of each, but my studies lead me to the belief that the southerly route would still be the less costly.

For the land tunnels, twin cast-iron tubes lined with concrete, built by the shield method, are proposed below water, and will be necessary whatever type of construction for the Narrows crossing is finally adopted. Rectangular sections of the ordinary steel bent and concrete type as shown on Plate No. 1 are proposed for tunnels above water in thickly populated districts. In Richmond, where part of the tunnel through soft ground, above water, is in undeveloped districts, the concrete section shown on Plate No. 1 is proposed. For the approaches to the tunnel, standard railroad construction is proposed.

ESTIMATES

The estimate of cost of construction of the shield-driven tunnels, and of the soft ground tunnel, has been derived from a detailed analysis of

contractor's plant, labor and materials, general office expenses, bond premiums, liability insurance, overhead superintendence, contingencies and profit. The rate of progress assumed for this work is based on the progress obtained in previous work of this character. All other estimates have been largely based on unit prices, which have been obtained from the cost of similar work carried out in New York City and elsewhere, modified to meet present-day prices.

The preliminary estimate of cost of a two-track tunnel on the southerly route is as follows:

Tunnel Construction:

Including connection to the Stapleton piers and based on present-day prices for labor and materials, with an allowance for contractors' contingencies and profit..... \$34,261,000

Equipment:

Including track, third rail, sub-stations, transmission, ventilation, pumping, lighting, signals, telegraph and telephone lines, etc..... 2,073,000

Engineering:

In which is included design, supervision and inspection, estimated at 6% of cost of tunnel construction and equipment..... 2,180,000

Administration and Legal Expenses:

Estimated at 2% of the cost of tunnel construction and equipment.... 727,000

Total..... \$39,241,000

Real Estate and Easements..... 1,500,000

Total..... \$40,741,000

Contingencies:

To provide for fluctuation in cost of labor and materials, claims, accidents, etc., estimated at 10% of the above total..... 4,074,000

Total..... \$44,815,000

Brooklyn Freight Connection, including Real Estate, Engineering, Administration and Contingencies..... 6,000,000

Total..... \$50,815,000

The time required for construction is estimated to be from five to six years.

RECOMMENDATIONS

It is recommended that authorization be given to prepare a contract and specifications for borings and for the preparation of the contract, specifications and plans for Twin Shield-Driven Cast Iron Tubes, and for alternative plans for a trench tunnel.

In conclusion, I desire to record my indebtedness to the members of the engineering staff for the valuable services rendered, and particularly to Principal Assistant Engineer Charles D. Drew, Resident Engineer William McK. Griffin and Designing Engineer Albert E. Hill.

Respectfully submitted,

J. B. SNOW,

Tunnel Engineer.



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